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(54) Method and apparatus for recognising characters printed on a document.

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(73) Proprietor: **International Business Machines Corporation**
Old Orchard Road
Armonk, N.Y. 10504(US)

(72) Inventor: **Mano, Takashi**
Ohmurasou 2goh 932-1 Takakura
Fujisawa-shi Kanagawa-ken(JP)

(74) Representative: **Killgren, Neil Arthur**
IBM United Kingdom Limited Intellectual Property Department Hursley Park
Winchester Hampshire SO21 2JN (GB)

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Description

Field of the Invention

The invention relates to a method and apparatus for recognizing characters printed on a document which is skewed relative to an image scanner.

Prior art and problems

The optical character recognition (OCR) technology has been used to recognize character images of a document. The OCR technology including steps of scanning the image of the document, comparing analog signals generated by the scanning operation with a threshold value to generate binary signals representing the image of the document, storing the binary signals in an image buffer, segmenting the character images, that is, breaking the image of the document into separate, distinct images of each character, recognizing the segmented character images, and outputting the results of the recognition.

The segmentation includes a step for separating character rows from each other. Referring to Fig. 1B, the image of the document 201 stored in the image buffer 202 is shown. The Fig. 1B shows that the document 201 has been scanned by a scanner without any skew of the document 201 with respect to the scanner. To separate the character rows from each other, a shadow projection technology has been used. The shadows of all characters are projected to generate projections 203 and 204. The projections 203 and 204 represent the positions of the first and second character rows in the image buffer in the Y axis. A problem arises when the document is skewed or inclined with respect to the scanner, as shown in Fig. 1C. The skewed documents 205 generates a long projection 207 into which the first and second character rows are included. In this case, the character images in the first character row are not separated from the character images in the second character row, whereby two character rows are treated as a single row, so that the characters in the both rows are mixed each other, and printed out in a single character row of an output print out indicating the results of the OCR of the document 205. To assure the separation of the character rows, the maximum skew angle for a standard A4 size document is about 1 degree. To perform the separation of the character rows for more skewed documents, the Japanese patent application 56-204636 indicates a solution in which the character rows are separated into plural blocks 209 as shown by vertical dotted lines 206 in the Fig. 1C, and a block projection, e.g. 208, is generated for each block, and the segmentation of the characters of a block 209 is made based upon the block projection 208. A continuity of one block 209 to the next block 210 is recognized to recognize the characters of one character row. Although the patent application 56-204636 somewhat improves the problem, it requires a complicated process for finding out the continuity of the blocks. An inherent problem included in the technology using the projections is that the technology does not successfully operate when the characters and a photograph are mixed in the horizontal direction of the document.

R. L. Hoffman and J. W. McCullough, Segmentation Methods for Recognition of Machine-Printed Characters, IBM Journal of Research and Development, vol. 15 (1971), 153-165, describes an algorithm for separation of touching characters. Scanned characters are examined of their vertical densities (i.e., number of black pixels in each vertical line), and low density lines will be selected as the boundaries of characters. Hence the method in the article apparently differs from that of the present invention.

K. Y. Wong, R. G. Casey, and F. M. Wahl, Document Analysis System, IBM Journal of Research and Development, vol. 26 (1982), 647-656, describes a general concept of an office system for document analysis. There is a description of a segmentation of characters using the projection method, as described hereinabove. The concept of the article apparently differs from that of the present invention.

R. G. Casey and G. Nagy, Recursive Segmentation and Classification of Composite Character Patterns, Proceedings of 6th International Conference on Pattern Recognition (1982), describes on a segmentation method in the case several characters are connected. As the first step of segmentation, a method presented in the Wong's article is used. The algorithm which is described will be used if the segmented block is supposed to be a connected characters. The concept of the article apparently differs from that of the present invention.

R. G. Casey and C. R. Jih, A Processor-Based OCR System, IBM Journal of Research and Development, vol. 27 (1983), 386-399, describes a general method for OCR systems. The algorithm is that characters are segmented after the baseline detection. Also the Decision Tree Algorithm is described here. The article does not disclose the concept of the present invention.

R. G. Casey, S. K. Chai, and K. Y. Wong, Unsupervised Construction of Decision Networks for Pattern Classification, Proceedings of IEEE 7th International Conference on Pattern Recognition (1984), describes a

recognition algorithm, and there is no description on the segmentation.

Summary of the invention

It is the object of the present invention to provide a method and apparatus for recognizing the characters and symbols of the document which is skewed or inclined with respect to an image scanner. This object is achieved with the method as defined in claim 1 and the apparatus as defined in claim 6.

A document is scanned by an image scanner and image data representing the image of the document is stored in an image storage means. Rectangles contacting and surrounding outer boundaries of each image of plural character rows in the image storage means are generated, and the positions of four edges of the rectangle in XY coordinates of the image storage means are detected. A size of a rectangle is calculated based upon the detected positions of the edges, and the size of each rectangle is compared with a expected size range for the characters and symbols to be recognized. The positions of the rectangles falling into the size range are stored in a first table as the position data wherein the position data of the rectangles of the characters and symbols over the plural character rows are arranged in the first list in the order from a rectangle at one end to a rectangle at the other end along the direction of the X axis of the XY coordinates.

The position data of the rectangles in the first list are sequentially fetched in the arranged order to detect a size of each rectangles to determine an average size of all rectangles stored in the first list. Again, the position data of the rectangles in the first list are sequentially fetched in the arranged order to find out a first rectangle falling into a size range settled based upon the average size. The fetch operations are continued to find out a second rectangle having a bottom left corner located within predetermined distances in the X and Y directions from a bottom left corner of the first rectangle. The fetch operations are continued to find out a third rectangle having a bottom left corner located within the predetermined distances in the X and Y directions from the bottom left corner of the second rectangle. The operations continues to find out a predetermined number of rectangles in one character row satisfying the condition. When the predetermined number of the rectangles have been found, a skew of the character row in the XY coordinates is calculated based upon the positions of the bottom left corners of these rectangles, and this detected skew is treated as the skew of the document.

Again, the position data of the rectangles in the first list are sequentially fetched in the arranged order, and the position of the bottom edge of each rectangle in the Y axis is corrected by the above skew of the document. The corrected position is called as a virtual position of the rectangle hereinafter. Among the virtual positions calculated during the fetch operations, one virtual position located at the highest position on the document is detected and the detected highest virtual position is stored in a register.

Again, the position data of the rectangles in the first list are sequentially fetched in the arranged order, and the virtual position of each rectangle is calculated again. And, a comparison is made as to whether the virtual position of each rectangle falls into a predetermined range from the highest position stored in the register. This range is selected to catch the rectangle of characters, such as the small characters "p", "y", having a leg extended below the base line of the character. During the fetch and compare operations, the position data of the rectangle which falls into the range is transferred from the first list to a second list, and at the end of the operations, the position data of the rectangle in the first character row have been stored in the second list in the order from the rectangle of the first character to the last rectangle of the last character.

An recognition unit sequentially fetches the position data of the rectangles stored in the second list, reads the image data in the image storage means surrounded by the rectangle specified by the position data, and recognizes the image data.

In order that the invention may be fully understood a preferred embodiment will now be described with reference to the accompanying drawings

Fig. 1A shows the image of the skewed document stored in the image buffer 23 which is recognized in accordance with the present invention.

Figs. 1B and 1C show a prior technology for segmenting character images on the document.

Fig. 2 shows a block diagram of circuit configurations for performing the method of the invention.

Fig. 3 shows a flowchart of the method of the invention.

Fig. 4 shows the detection of the positions of four edges of the rectangle which contacts the outer boundaries of the character A.

Figs. 5A, 5B and 5C show the detection of the rectangle, the bottom left corner of which is located within a predetermined distances in the X and Y axes from the bottom left corner of the preceding rectangle.

Fig. 6 shows the generation of the virtual positions of the rectangles.

1 ..... Document
20 ..... Control unit
21 ..... Scanner
22 ..... Threshold circuit
23 ..... Image buffer
24 ..... Character position detect device
25 ..... Table memory
26 ..... Skew calculation device
27 ..... One row select device
31 ..... Recognition unit
32 ..... Output buffer

Description of embodiment

Referring to Fig. 1A, a document 1 including plural character rows is shown. For simplifying the drawing, only three character rows are shown. Further, the spaces between the characters in both the horizontal and vertical directions on the document 1 are more expanded than that of the actual document for understanding the present invention. Each character row, therefore, could include more characters than that shown in the Fig. 1A.

The document 1 is shown as being inclined or skewed by a skew angle in the XY coordinates.

The document 1 is scanned by a document scanner 21 shown in Fig 2. The document scanner 21 provided with a light source, an optical sensor array and means for relatively moving the document 1 to the optical sensor array. The optical sensor array includes plural optical sensor elements, such as Charge Coupled Devices, arranged in a density or resolution of 240 pels/inch. For example, 2016 optical sensor elements arranged in one row in a horizontal direction are required to scan A4 size document with a width of 210 mm. Each element defines one picture element (pel). The light from the light source is reflected by the document 1, and the reflected light representing an image of the document 1 is detected by the optical sensor array, which generates electrical analog signals of the pels. The analog signals are supplied to a threshold circuit 22 shown in the Fig. 2 which compares each of the analog signals with a threshold level. If the analog signal exceeds the threshold level, the threshold circuit 22 generates binary "0" signal representing a white level. If the analog signal does not exceed the threshold level, the threshold circuit 22 generates binary "1" signal representing a black level. The optical sensor elements arranged in one line in the horizontal direction define a scan line 2 shown in the Fig 1A. As the document 1 is relatively moved to the optical sensor elements, the scan line 2 moves downwardly in the Y direction on the document 1, and the image data of the document 1 is gradually stored in an image buffer 23.

A control unit 20 is shown in the Fig. 2. The control unit 20 controls the operations of all blocks in the Fig. 2. For simplifying the drawings, however, the connections between the control unit 20 and the blocks are not shown in the Fig. 2.

The processing operations in accordance with the present invention are generally classified into the followings:

(A) Scan and store of the image of the document
(B) Segmentation of character images and detection of the position thereof to form a first list in a table memory 25
(C) Detection of skew angle of the document
(D) Reorder of the contents of the first list in the table memory 25 and assemble of a second list in a table memory 30
(E) Recognition of the character image specified by the contents of the second list

The followings are detail descriptions of the (A) through (E).

(A) Scan and store of the image of the document

It is assumed that the image buffer 23 has a small storage capacity 23A for storing a portion of the skewed document 1 including three character rows.

The control unit 20 responds to an operator's depress of a start switch of the scanner 21 or the termination of the processes of the step (E) described hereinafter to start the store operation of the image buffer 23. Since the portion shown in the Fig. 1A is the starting part of the documents 1, the depress of the start switch causes the control unit 20 to start the operations. The control unit 20 controls the scanner 21, the threshold circuit 22 and the image buffer 23 to start the scan operations, to supply the electrical signals

from the scanner 21 to the threshold circuit 22, and to store the binary signals representing the image data from the threshold circuit 22 into the image buffer 23. The control unit 20 monitors the scan and store operations, stops them and start the next operations (B) when the image buffer 23 is filled with the image data. The operations are shown as blocks 301 and 302 in the Fig. 3.

(B) Segmentation of character images and detection of the positions thereof to form a first list in a table 25

The control unit 20 activates a character position detect device 24. It accesses the image buffer 23 to sequentially fetches the data of the horizontal bit rows in the order from top to bottom. The purposes of the operations are (i) to segment each character image, i.e. to break the scanned image of the document into separate, distinct images of each character, by generating rectangles each of which surround each character image, (ii) to detect the positions of the rectangles in the XY coordinate of the image buffer 23 and (iii) to store the data representing the positions of the rectangles in a table 25 (Fig. 2) to form a first list. The operations (B) are shown as a block 303 in the Fig. 3. The detail descriptions of the above (i), (ii) and (iii) are as follows.

(i) The horizontal data bit lines of the image buffer 23 are sequentially fetched in the order from the top to the bottom by the character position detect device 24. The character position detect device 24 determines the presence of the bits 1, i.e. black pels, in each bit line, generates a rectangle which contacts outer edge of the pattern of the black pels, and calculates the position of the rectangle in the XY coordinate. It is noted that the document 1 may include smear black blocks, long lines, a photograph, etc. which are smaller or larger than expected sizes of the characters and symbols to be recognized by the character recognition unit 31. The character position detect means 24 detects these objects and ignores them.

Describing in more detail with referring to the Figs. 1A and 4, the scan line 2 corresponds to the data bit line of image buffer 23. When the bit line 2A is supplied to the character position detect means 24, it detects the black pel of the top of the character A. As the subsequent bit line group 41 are supplied to the character position detect device 24, it generates a rectangle 42. The character position detect device 24 determines the continuity of the black pels or the image in the supplied bit lines, and grows up the rectangle if it detects the continuity. Referring to the Fig. 4, the rectangle is gradually grown up as shown by 43 and 44, due to the presence of the continuity of the black pels in the bit line groups 45 and 46. The bit line 2C is the final bit line of the bit line group 46.

The character position detect device 24 detects the lack of continuity of the black pel in the Y direction by determining the bit line 2C + 1, i.e. next bit line to the bit line 2C. In the same manner, the character position detect device 24 detects the lack of continuity in the X direction.

Then, the character position detect device 24 detects the termination of the black pels in the X direction at the bit line 2B and the termination of the black pels in the Y direction at the bit line 2C, and terminates or fixes the growth of the rectangle, whereby the rectangle 44 contacting the outer edges of the continuous black pel group of the character A is generated.

(ii) When the character position detect device 24 completes the rectangle 44, it calculates the following positions of the rectangle 44 surrounding the character "A" in the XY coordinates, as shown in the Fig. 4.

YTA ... Position of the Top edge of the rectangle of the character A in the Y axis in the image buffer 23

YBA ... Position of the Bottom edge of the rectangle of the character A in the Y axis in the image buffer 23

XLA ... Position of the Left edge of the rectangle of the character A in the X axis in the image buffer 23

XRA ... Position of the Right edge of the rectangle of the character A in the X axis in the image buffer 23

Wherein the first character represents X or Y axis, the second character represents Top, Bottom, Left or Right of the rectangle and the third character represents the character surrounded by the completed rectangle.

It is noted that the character position detect device 24 does not perform a recognition as to whether the continuous black pel group represents the character A. The character position detect device 24 merely detects the rectangles contacting each of the continuous black pel groups and its position and size in the XY coordinates.

Next, the character position detect device 24 determines as to whether the sizes in the X and Y directions of the rectangle falls into a range settled for the expected sizes of the characters and symbols to be recognized. As described hereinbefore, the purpose of the determination of the sizes of the completed rectangle is to ignore the black block, the long line, the photograph sizes of which are out of the expected sizes of the characters and symbols. When the character position detect device 24 finds out the rectangle of the sizes out of the expected sizes, the character position detect device 24 ignores

the rectangle without storing the position data of such rectangle in the next step (iii).
(iii) The character position detect device 24 stores the position data YTA, YBA, XLA and XRA into an entry, e.g., address 2, of a table memory 25 to form the first list, as shown in a table 1.

TABLE 1: FIRST LIST

ADDRESS	TOP EDGE	BOTTOM EDGE	LEFT EDGE	RIGHT EDGE	POINTER
1					2
2	YTA	YBA	XLA	XRA	0

The entry address 1 is the initial entry when the table access is started. The device 24 stores the address 2 as the pointer of the entry 1 which indicates that the next entry to be accessed is the entry 2. The value 0 of the pointer of the entry 2 represents that the entry 2 is the last entry, so that the table access operations are terminated.

In the same manner, the character position detect device 24 completes a rectangle 45 surrounding the character "r", as shown in the Fig. 1A, and calculates the position data YTr, YBr, XLr and XRr. The bottom edge of the rectangle 45 lies on a bit line 2D. The character position detect device 24 stores the data YTr, YBr, XLr and XRr into an entry address 3, as shown below, compares the XLr with the XLA to determine which of the rectangles is close to the value X=0. In this case, since the rectangle of character A is located at the left side of rectangle of the character r, the character position detect device 24 stores the address 3 as a pointer in the entry 2.

TABLE 2: FIRST LIST

ADDRESS	TOP EDGE	BOTTOM EDGE	LEFT EDGE	RIGHT EDGE	POINTER
1					2
2	YTA	YBA	XLA	XRA	3
3	XTr	YBr	XLr	XRr	0

The contents of the first list in the table memory 25 when the characters A, r, B and C have been processed are as follows:

TABLE 3: FIRST LIST

ADDRESS	TOP EDGE	BOTTOM EDGE	LEFT EDGE	RIGHT EDGE	POINTER
1					5
2	YTA	YBA	XLA	XRA	3
3	YTr	YBr	XLr	XRr	0
4	YTB	YBB	XLB	XRB	2
5	YTC	YBC	XLC	XRC	4

It is noted that as the process proceeds, the pointers of the entries have been changed to access the position data in the sequence of C, B, A and r, i.e. in the direction from left to right on the document 1. That is, the table entry 1 stores the pointer 5, which addresses the entry 5 storing the data of the rectangle of the character C and the pointer 4, which addresses the entry 4 storing the position data of the rectangle of the character B and the pointer 2, which addresses the entry 2 storing the position data of the rectangle of the character A and the pointer 3, which addresses the entry 3 of the rectangle of the character r.

It is apparent that whenever the character position detect device 24 completes a new rectangle, the device 24 compares the position in the X axis of this new rectangle to the X axis positions of the old rectangles already stored in the first list, and modifies the pointers of the new and old rectangles to cause the access operations for them to be made in the order from the left end rectangle to the right end rectangle in the direction of the X axis. The contents of the first list in the table memory 25 when all rectangles for the character and symbol images have been processed are shown in the following table 4.

TABLE 4: FIRST LIST

ADDRESS	TOP EDGE	BOTTOM EDGE	LEFT EDGE	RIGHT EDGE	POINTER
1					7
2	YTA	YBA	XLA	XRA	9
3	YTr	YBr	XLr	XRr	
4	YTB	YBB	XLB	XRB	10
5	YTC	YBC	XLC	XRC	12
6	YTq	YBq	XLq	XRq	11
7	YTD	YBD	XLD	XRD	13
8	YTP	YBP	XLP	XRP	14
9	YT,	YB,	XL,	XR,	15
10	YTn	YBn	XLn	XRn	16
11	YTz	YBz	XLz	XRz	3
12	YTm	YBm	XLm	XRm	17
13	YT1	YB1	XL1	XR1	18
14	YTy	YBy	XLy	XRy	6
15	YTx	YBx	XLx	XRx	8

16	YTw	YBw	XLw	XRw	2
17	YTu	YBu	XLu	XRu	4
18	YTt	YBt	XLt	XRt	5

The pointers in the first list in the table memory 25 indicates that the initial access to the first list is made at the entry address 1 and the remaining entries are accessed in the sequence shown in the lower part of the Fig. 1A. That is, in the first list shown in the table 4, plural position data of the rectangle are arranged in the order from the left most rectangle to the right most rectangle in the direction of the X axis of the XY coordinates of the image buffer 23. The control unit 20 detects the termination of the operations (B) and starts the next operations (C).

(C) Detection of skew of the document

In the operation, the rectangles which belong to any one of the character rows of the document 1 are picked up and the skew of the document 1 in the XY coordinates is detected.

Detail operations are as follows:

(i) The control unit 20 activates a skew calculation device 26 shown in the Fig. 2. The skew calculation device 26 accesses all entries of the first list (TABLE 4) of the table memory 25 in the order specified by the pointers to fetch the position data, i.e. the top, bottom, left and right edge values of each rectangle, and calculates the size of each rectangle in both the X and Y directions. And, the skew calculation device 26 calculates an average size of all rectangles. The operations are represented as a block 304 in the Fig. 3.

(ii) The skew calculation device 26 again accesses all entries of the first list (TABLE 4) in the order specified by the pointers to find out a first rectangle falling into an allowed range from the average size. When the skew calculation unit 26 finds out the first rectangle, it stores in a register, not shown, the data of the bottom and left, i.e. the bottom left corner of the first rectangle.

In the exemplary case, the first rectangle is the rectangle of the character D. And, the skew calculation device 26 continues the access of the first list to find out a second rectangle, which is located right side of the first rectangle, which falls into said allowed range and satisfies the following conditions (1) and (2):

$$X_f + X_1 < X_s < X_f + X_2 \quad (1)$$
$$Y_f - Y_1 < Y_s < Y_f + Y_2 \quad (2)$$

These values represent the positions and distances shown in Fig. 5A.

X_f, Y_f Position of the bottom-left corner of the first rectangle 51
X_s, Y_s Position of the bottom-left corner of the second rectangle 52
X_1 Predetermined distance from X_f
X_2 Predetermined distance from X_f
Y_1 Predetermined distance from Y_f, and
Y_2 Predetermined distance from Y_f

The value X_1 is experimentally selected to accommodate the case that first rectangle is the narrowest one for the narrow character, such as "1". The value X_2 is also experimentally selected to accommodate the case that the second rectangle is double-spaced from the first rectangle. The values Y_1 and Y_2 are also experimentally selected to accommodate the case that the maximum skew angle of the document 1 is 5°. The other consideration made to select the value Y_2 is to reject the character, such as "p", in the Fig. 5C, having a long extension below its base line, since the skew of the document 1 is determined based upon the positions of the bottom-left corners of the rectangles, as stated hereinbelow.

The values X_1, X_2, Y_1 and Y_2 define an area 53, as shown in the Figs. 5A, 5B and 5C. The conditions (1) and (2) determine if the bottom-left corner (X_s, Y_s) of the second rectangle 52 falls into the area 53. The second rectangle 52 in the Fig. 5A satisfies the conditions (1) and (2). The second rectangle 55 in Fig. 5B does not satisfy the conditions (1) and (2). The second rectangle 57 in Fig. 5C satisfies the condition (1), but does not satisfy the condition (2).

When the skew calculation device 26 finds out the second rectangle, in the case of the Fig. 1A, the rectangle of the character C, which satisfies the conditions (1) and (2), it stores in the register the position data of the bottom and the left of the second rectangle. It is noted that the register of the skew calculation device 26 now stores the position data of the bottom-left corners of the first and second rectangles. And, the skew calculation device 26 continues the access of the first list (TABLE 4) to find out the third rectangle which has a bottom-left corner falling into the area 53 of the second rectangle. When it finds out the third rectangle, in this case the rectangle of the character B, it stores the position data of the bottom and the left of the third rectangle in the register. In this manner, the skew calculation device 26 finds out a series of the rectangles which have the bottom-left corner fallen into the area 53 of the preceding rectangle, and determines whether the number of the found rectangles is equal to a predetermined number, such as 15. The number was selected under the assumption that a standard English letter of a standard type format includes at least 15 average size characters in one character row. Any other number could be used.

At the termination of the first search of the first list started by specifying the rectangle of the character D as the first rectangle, the skew calculation device 26 has found out the four rectangles of the characters D, C, B and A. Since this number is smaller than 15, the skew calculation device 26 resets the data stored in the register, and starts the second search of the first list by specifying the rectangle of the character C as the first rectangle. It is apparent that the searches repeated three times by specifying as the first rectangle the rectangles of the characters C, B and A, respectively do not find out 15 rectangles each of which has the bottom-left corner falling into the area 53, i.e. the conditions (1) and (2), of the preceding rectangle. The skew calculation device 26 starts the fifth search by specifying the rectangle of the character 1 as the first rectangle. It is assumed that the second character row beginning with the character 1 of the document 1 in the Fig. 1A includes 15 average size characters, though only 7 characters are shown in the Fig. 1A. At the termination of the fifth search, the skew calculation device 26 knows that the 15 rectangles have been found. And, the position data representing the bottom-left corners of the found 15 rectangles have been stored in the register. The skew calculation device 26 fetches the position data in the register, and generates a skew angle of the second character row by using a method of least square, which has been well known in the art. And, the skew calculation device 26 keeps the skew angle for use of it as the skew angle of the document 1 in the latter process.

The operations are shown as a block 305 in the Fig. 3. The control unit detects the termination of the operations (C) and starts the next operations (D).

(D) Reorder of the contents of the first list in the table memory 25 and assemble of a second list in a table memory 30

The purpose of the reorder of the contents in the first list is to find out the rectangles of the characters and symbols belonging to one character row among all rectangles stored in the first list, to fetch the position data of the characters of these rectangles, and to store them in a table memory 30 to form a second list. The following detail description relates to the above operations for storing the position data of the rectangles of the characters D, C, B, A belonging to the first character row of the document 1 shown in the Fig. 1A, into the table memory 30 to form the second list.

Detail operations are as follows.

(i) The control unit 20 activates one row select device 27 shown in the Fig. 2. The one row select device 27 receives the value of the skew angle of the document 1 from the skew calculation device 26 and stores it in a register 28. The one row select device 27 accesses the first list (TABLE 4) in the table memory 25 to sequentially fetch the bottom and left values of each rectangle in the order specified by the pointers, i.e. in the order of the characters shown in the lower part of the Fig. 1A. The first values YBD and XLD fetched from the first list represent the position of the bottom-left corner of the rectangle of the character D in the XY coordinates. The one row select device 27 performs the following calculations:

$$YB = (XLD \times \tan\theta) + YBD \quad (3)$$

The value YB represents a virtual position of the bottom-left corner of the rectangle in the Y axis when the document 1 is rotated in a clockwise direction to correct the skew angle θ, as shown in the Fig. 6. The virtual position YB is stored in a register 29 of the one row select device 27. Next, the one row select device 27 fetches the position data YBI and XLI of the rectangle of the character 1 and generates the virtual value YB for the bottom left corner of the rectangle, and compares the YB for the rectangle of the character 1 with the value YB for the rectangle of the character D to determine which of the both values is smaller. In this case, the YB for the rectangle of the character D is selected, and the content of the register 29, i.e. the value YB for the rectangle of the character D is not changed. In this manner, the one row select device 27 continuously accesses all position data in the first list (TABLE 4), and generates the virtual value YB of each rectangle, and compares the new value YB with the old value YB stored in the register 29, and replaces the old value YB by the new value YB if the new value is smaller than the old value YB, so that the smallest value YB among all rectangles is stored in the register 29. The smallest value YB indicates the value YB of the rectangle in the first character row, which is located at the highest position on the document, as shown in the Fig. 6. The operations are shown as a block 306 in the Fig. 3.

(ii) The one row select device 27 again accesses the first list (TABLE 4) in the table memory 25 in the order specified by the pointer, i.e. in the order shown in the lower part of the Fig. 1A. The one row select device 27 fetches the position data YBD and the XLD of rectangle of the character D, and performs the calculation (3) as described hereinabove. And, the one row select device 27 determines whether the calculated value YB falls into a range 61 shown in Fig. 6, or not. The lower limit of the range 61 is selected to catch the rectangles of the characters having the long leg below the base line, such as the characters p and y. In this case, the answer is YES, then the one row select device 27 decides as that the character D belongs to the first character row, and fetches the four position data of the rectangle of the character D, i.e. YTD, YBD, XLD and XRD of the entry 7 of the first list (TABLE 4) in the table memory 25 and stores them in an entry 1 of the second list of the table memory 30. Also, the one row select device 27 replaces the pointer 7 in the entry 1 of the first list by the pointer 13 in the entry 7 of the rectangle of the character D, and deletes the contents in the entry 7.

The modification of the pointer is performed for skipping the delated entry 7 and pointing the entry 13 of the next character 1.

Next, the one row select device 27 fetches the four position data of the rectangle of the character 1 in the entry 13 of the first list and repeats the calculation and the comparison. The comparison indicates that the calculated value YB of the rectangle of the character 1 does not fall into the range 61 settled for the first character row, that is, the character 1 does not belong to the first character row. The one row select device 27 does nothing anymore on the rectangle of the character 1, and accesses the entry 18 specified by the pointer 18 in the entry 13, and repeats the above calculation and comparison. The comparison again indicates that the calculated value YB of the rectangle of the character "t" does not fall into the range 61, hence the one row select device 27 terminates the process of the rectangle of the character "t" and accesses the entry 5 which is specified by the pointer 5 in the entry 18. The entry 5 stores the four position data of the rectangle of the character C in the first character row. The comparison indicates that the calculated value YB of the rectangle of the character C falls into the range 61, and the one row select device 27 decides that the character C belongs to the first character row. The one row select device 27 fetches the four position data of the rectangle of the character C, i.e. YTC, YBC, XLC and XRC, of the entry 5 of the first list and stores them in an entry 2 of the second list of the table memory 30. Also, the one row select device 27 replaces the pointer 5 in the entry 18 of the first list by the pointer 12 in the entry 5, and deletes the contents of the entry 5, whereby the entry 5 is skipped in the latter operations and the rectangle of the character "t" is followed by the rectangle of the character "m". In this manner, the one row select device 27 repeats the above operations for each rectangle in the first list. The contents of the modified first list and the new second list at the completion of the operations for all entries of the first list are shown in the Tables 5 and 6, respectively. The above assembly of the second list and the modification of the first list are shown as a block 307 in the Fig. 3.

The control unit 20 terminates the operations (D) and starts the next operations (E).

TABLE 5: MODIFIED FIRST LIST

ADDRESS	TOP EDGE	BOTTOM EDGE	LEFT EDGE	RIGHT EDGE	POINTER
1					13
2					
3	YTr	YBr	XLr	XRr	0
4					
5					
6	YTq	YBq	XLq	XRq	11
7					
8	YTP	YBP	XLP	XRP	14
9	YT,	YB,	XL,	XR,	15
10	YTn	YBn	XLn	XRn	16
11	YTz	YBz	XLz	XRz	3
12	YTm	YBm	XLm	XRm	17
13	YT1	YB1	XL1	XR1	18
14	YTy	YBy	XLy	XRy	6
15	YTx	YBx	XLx	XRx	8

16	YTw	YBw	XLw	XRw	9
17	YTu	YBu	XLu	XRu	10
18	YTt	YBt	XLt	XRt	12

TABLE 6: SECOND LIST

ADDRESS	TOP EDGE	BOTTOM EDGE	LEFT EDGE	RIGHT EDGE
1	YTD	YBD	XLD	XRD
2	YTC	YBC	XLC	XRC
3	YTB	YBB	XLB	XRB
4	YTA	YBA	XLA	XRA

(E) Recognition of the character image specified by the contents of the second list

It is noted that the position data stored in the second list, i.e. YTD, YBD, XLD, XRD, ..., YTA, YBA, XLA, XRA, indicates the positions of the rectangles in the image buffer 23, each of which surrounds the character images D, C, B, A stored in the image buffer 23.

The control unit 20 starts the operation (E) by activating the recognition unit 31. The recognition unit 31 is provided with decision trees for recognizing the character images, which have been well known in the art. The detail description of the decision trees, therefore, is not made in the specification. The recognition unit 31 accesses the entry 1 of the second list in the table memory 30 to fetch the position data YTD, YBD, XLD and XRD which represent the position of the rectangle surrounding the character D. And, the recognition unit 31 fetches the image data in the image buffer 23 surrounded by the rectangle. The recognition unit 31 recognizes the image of the character D by use of the decision tree and stores the results in an output buffer 32. Next, the recognition unit 31 fetches the position data YTC, YBC, XLC and XRC, of the entry 2 in the second list and performs the above operations to store the results of the recognition of the character C in the output buffer 32. The recognition unit 32 repeats the above operations until all position data stored in the second list have been used. The operations are shown as a block 308 in the Fig. 3.

The control unit 20 detects the termination of the operations (E) and supplies the contents of the output buffer 32 to an output device. It is noted that the four characters of the first character row of the document 1, shown in the Fig. 1A have been recognized. The control unit 20 determines the highest position of the top edge of the rectangles of the characters in the first list, i.e. the position of the top edge of the rectangle of the character r. Referring to the Fig. 1A, the top edge is located at the bit line 2B. The control unit 20 knows that an upper storage area between the top bit line and the bit line 2B of the image buffer 23 is now available for storing the next document image. The control unit 20 activates the scanner 21 to store the above next document image into the upper storage area, and the control unit 20 modifies the addresses of the bit lines of the upper storage area to continue to the address 23B which is the last bit line of the initially stored document image. That is, the top bit line of the upper storage area is assigned with an address 23B + 1, the second bit line is assigned with an address 23B + 2, and so on, whereby the continuity of the

newly stored document image in the upper storage area to the initially stored image in the image buffer 23 is maintained.

When the image buffer 23 is filled with the new document image, the control unit 20 performs the operations (B) through (E). When the operation (E) is completed, the control unit 20 repeats the above operations until all characters in the document 1 have been recognized.

At the completion of the recognition of each character row the control unit 20 supplies the output device, such as a printer, a display device, etc. with the contents of the output buffer 32, whereby the operator could have the results of the character recognition of the document 1.

Although the invention has been described by using the document 1 skewed or inclined in the counterclockwise direction, it is apparent that the invention could recognizes the characters of the document which is skewed in the clockwise direction.

In the embodiment, the segmentation of the characters and symbols is described for the document with the characters in the words are spelled in the direction from left to right. The invention is capable of segmenting the characters and symbols spelled in an opposite direction, i.e. from right to left by arranging the pointers in the first list in the order from the right most rectangle to the left most rectangle in the character row by arranging the area 53 of the Fig. 5A on the left side of the rectangle 51.

Using the present invention for recognizing the document including the three kinds of fonts, i.e. Courier 10, Courier 12 and Prestige Elite 12 with single vertical space between character rows it has been found that the characters of the document skewed by the maximum skew angle of 6 in the clockwise or counterclockwise direction have been recognized with clear separation of the character rows, in other words, without appearing the characters of the second character row shown in the Fig. 1A into the first and third character rows.

Claims

1. A method of recognising characters printed on a document, the characters being arranged on the document in character rows, the method comprising the steps of:
storing an image of the document in image storage means;
determining the XY coordinate positions of rectangles in the stored image that are parallel to the X and Y axes, each rectangle defining the outer boundary of the image of a character and being formed by detecting the continuity of a character image over successive bit lines of the image;
forming a first list of the rectangle position data in which the rectangles are arranged in order along the X axis of the stored image according to their X coordinate position data;
determining the identity of a plurality of rectangles as being within a particular character row by detecting whether the position of a predefined point on each of these rectangles falls within a predetermined area defined with respect to another one of these rectangles in the first list and based on the position data of the identified rectangles calculating the angle at which the character row is skewed with respect to the XY coordinates of the image storage means;
based on the calculated skew angle, determining all the constituent rectangles of each character row; and rearranging the rectangle position data into a second list according to the membership to a character row;
supplying from the image storage means to a character recognition means the image data within each of the rectangles in the order specified in the second list.

2. A method as claimed in Claim 1, wherein the step of determining the positions of the rectangles includes a step of determining whether each rectangle has a size which falls into a predetermined size range for the characters to be recognised and during the step of forming a list of position data, ignoring those rectangles which fall outside the range.

3. A method as claimed in Claim 1, wherein the position data represents the positions of top, bottom, left and right edges of the rectangle in the XY coordinates.

4. A method as claimed in Claim 1, wherein the step of determining the identity of a plurality of rectangles within a particular character row includes a step of searching the first list to detect a predetermined number of rectangles, with a bottom left corner of one rectangle being located within a predetermined distance in the X and Y axes from a bottom left corner of the preceding rectangle, and a step of performing calculations of the positions of bottom left corners of the detected rectangles to detect the skew of the character row and hence of the document.

5. A method as claimed in Claim 1, wherein the step of determining all the constituent rectangles in each character row includes the steps of:

sequentially reading the position data of the rectangles in the first list in the arranged order;

generating a virtual position of each rectangle by correcting the position in the Y axis of each rectangle in the first list by the skew;

storing in a register the virtual position of the rectangle located at the highest position on the document;

sequentially reading again the position data of the rectangles in the first list;

generating the virtual position of each rectangle and determining whether the generated virtual position falls into a predetermined range from the virtual position stored in the register; and

transferring the position data of a rectangle in the first list, the generated virtual position of which falls into the predetermined range, to the second list.

6. Character recognition apparatus for recognising characters printed on a document comprising:

image storage means (23) for storing an image of the document;

means (24) for determining the XY coordinate positions of rectangles in the stored image that are parallel to the X and Y axes, each rectangle defining the outer boundary of the image of a character and being formed by detecting the continuity of a character image over successive bit lines of the image;

means for forming a first list of the rectangle position data in which the rectangles are arranged in order along the X axis of the stored image according to their X coordinate position data;

skew calculation means (26) for determining the identity of a plurality of rectangles as being within a particular character row by detecting whether the position of a predefined point on each of these rectangles falls within predetermined area defined with respect to another one of these rectangles in the first list and based on the position data of the identified rectangles calculating the angle at which the character row is skewed with respect to the XY coordinates of the image storage means;

means (27) for determining all the constituent rectangles of each character row based on the calculated skew angle; and rearranging the rectangle position data into a second list (30) according to the membership to a character row;

character recognition means (31) for fetching from the image storage means the image data within each of the rectangles in the order specified in the second list.

7. Character recognition apparatus as claimed in Claim 6, wherein the means for determining the positions of rectangles determines as to whether a size of each rectangle falls within a predetermined size range of the characters to be recognised, and generates the position data only for rectangles falling into the size range.

8. Character recognition apparatus as claimed in Claim 6, wherein the position data represents upper, bottom, left and right edges of the rectangles in XY coordinates of the image storage means.

9. Character recognition apparatus as claimed in Claim 7, wherein the first list is stored in a first table memory; and

wherein the skew calculation means sequentially reads the position data of the rectangles of the first list in the arranged order, detects a predetermined number of rectangles, in which a bottom left corner of one rectangle is located within predetermined distances in the X and Y directions from a bottom left corner of the preceding rectangle and detects a skew of the document based upon the positions of bottom left corners of the detected rectangles, and wherein the means for determining all the constituent rectangles of each character row, sequentially reads again the position data of the rectangles of the first list in the arranged order to generate a virtual position of each rectangle which is a Y axis position corrected by the skew, storing a virtual position located at a highest position of the document into a register, sequentially reads again the position data of the first list in the arranged order to generate the virtual positions of the rectangles, determines as to whether the generated virtual positions falls into a predetermined range from the virtual position in the register, and transfers the position data of rectangle having the virtual position falling into the predetermined range to a second list.

Patentansprüche

1. Eine Methode zur Erkennung von gedruckten Zeichen auf einem Beleg, auf dem die Zeichen auf dem Beleg in Zeichenreihen angeordnet sind, das Verfahren mit Schritten enthaltend
Speicherung eines Bildes des Belegs in Bildspeichermitteln;
Bestimmung der XY-Koordinatenpositionen der Rechtecke in dem gespeicherten Bild, die parallel zu x- und y-Achsen sind, jedes Rechteck die äußere Grenze des Bildes eines Zeichens definiert und durch Erkennung der Kontinuität eines Zeichenbildes über die aufeinanderfolgenden Bitzeilen des Bildes gebildet werden;
Bildung einer ersten Liste der Positionsdaten der Rechtecke, in denen die Rechtecke in der Reihenfolge entlang der x-Achse des gespeicherten Bildes gemäß ihrer X-Koordinatenpositionsdaten angeordnet sind;
Bestimmung der Identität einer Vielzahl von Rechtecken, die innerhalb einer besonderen Zeichenreihe durch Feststellung erkannt werden, ob die Position eines zuvor bestimmten Punktes auf jedem dieser Rechtecke innerhalb eines zuvor bestimmten Bereichs liegt, der, bezogen auf ein anderes von diesen Rechtecken, in der ersten Liste definiert wurde und auf den Positionsdaten von den identifizierten Rechtecken basiert, Berechnen des Winkels bei dem die Zeichenreihe schräggestellt wird, bezogen auf die XY-Koordinaten der Bildspeichermittel;
basierend auf dem berechneten Schrägstellungswinkel; und erneute Anordnung der Positionsdaten in einer zweiten Liste gemäß der Zugehörigkeit zu einer Zeichenreihe;
Lieferung von den Bildspeichermitteln an ein Zeichenerkennungsmittel der Bilddaten innerhalb jeder von den Rechtecken in der in der zweiten Listen spezifizierten Reihenfolge.

2. Eine Methode wie in Anspruch 1, wobei der Schritt zur Festlegung der Positionen der Rechtecke einen Schritt zur Festlegung enthält, ob jedes Rechteck eine Größe hat, die in einen zuvor bestimmten Größenbereich für die zu erkennenden Zeichen fällt und während des Schritts zur Bildung einer Liste mit Positionsdaten gebildet wird, diese Rechtecke zu ignorieren, die außerhalb des Bereichs liegen.

3. Eine Methode wie in Anspruch 1, wobei die Positionsdaten die Positionen von oberen, unteren, linken und rechten Kanten der Rechtecke in den XY-Koordinaten darstellen.

4. Eine Methode wie in Anspruch 1, wobei der Schritt zur Bestimmung der Identität von einer Vielzahl von Rechtecken innerhalb einer besonderen Zeichenreihe einen Schritt zum Suchen enthalten, um eine zuvor bestimmte Anzahl von Rechtecken in der ersten Liste zu erkennen, mit einer unteren linken Ecke von einem Rechteck, das innerhalb einer zuvor bestimmten Entfernung in der x- und y-Achse von einer unteren linken Ecke des vorherigen Rechtecks liegt und einen Schritt zur Durchführung von Berechnungen der Positionsdaten von unteren linken Ecken der erkannten Rechtecke, um die Schrägstellung der Zeichenreihe und somit des Belegs zu erkennen.

5. Ein Verfahren wie in Anspruch 1, wobei der Schritt zur Festlegung der Rechtecke, aus denen jede Zeichenreihe gebildet wird, Schritte enthält
zum schrittweisen Lesen der Positionsdaten der Rechtecke in der ersten Liste in der angeordneten Reihenfolge;
zur Erzeugung einer virtuellen Position von jedem Rechteck durch Korrektur der Position in der y-Achse von jedem Rechteck in der ersten Liste durch die Schrägstellung;
zum Speichern in einem Register der virtuellen Position des Rechtecks, das sich in der höchsten Position des Belegs befindet;
zum erneuten schrittweise Lesen der Positionsdaten der Rechtecke in der ersten Liste;
zur Erzeugung der virtuellen Position von jedem Rechteck und Festlegung, ob die erzeugte virtuelle Position in einen zuvor bestimmten Bereich von der in einem Register gespeicherten virtuellen Position fällt; und
zur Übertragung der Positionsdaten eines Rechtecks in die erste Liste, der erzeugten virtuellen Position, welche in den zuvor bestimmten Bereich fällt, in die zweite Liste.

6. Gerät zur Zeichenerkennung zur Erkennung von gedruckten Zeichen auf einem Beleg mit:
Bildspeichermitteln (23) zur Speicherung eines Bildes von dem Beleg;
Mittel (24) zur Festlegung der XY-Koordinatenpositionen in dem gespeicherten Bild, die parallel zu den x- und y-Achsen sind, jedes Rechteck die äußere Grenze des Bildes eines Zeichens definiert und

durch Erkennung der Kontinuität eines Zeichenbildes über die aufeinanderfolgenden Bitzeilen des Bildes gebildet werden;
Mittel zur Bildung einer ersten Liste der Positionsdaten der Rechtecke, in denen die Rechtecke in der Reihenfolge entlang der x-Achse des gespeicherten Bildes gemäß ihrer X-Koordinatenpositionsdaten angeordnet sind;
Mittel zur Schrägstellungsberechnung (26) zur Bestimmung der Identität einer Vielzahl von Rechtecken, die innerhalb einer besonderen Zeichenreihe durch Feststellung erkannt werden, ob die Position eines zuvor bestimmten Punktes auf jedem dieser Rechtecke innerhalb eines zuvor bestimmten Bereichs liegt, der, bezogen auf ein anderes von diesen Rechtecken, in der ersten Liste definiert wurde und auf den Positionsdaten von den identifizierten Rechtecken basiert, Berechnen des Winkels bei dem die Zeichenreihe schräggestellt wird, bezogen auf die XY-Koordinaten der Bildspeichermittel;
Mittel (27) zur Feststellung aller Rechtecke, aus denen jede Zeichenreihe gebildet wird, basierend auf dem berechneten Schrägstellungswinkel; und erneute Anordnung der Positionsdaten in einer zweiten Liste gemäß der Zugehörigkeit zu einer Zeichenreihe;
Mittel zur Zeichenerkennung (31), um von den Bildspeichermitteln die Bilddaten innerhalb jeder der Rechtecke in der Reihenfolge abzurufen, die in der zweiten Liste angegeben sind.

7. Gerät zu Zeichenerkennung wie in Anspruch 6, wobei die Mittel zur Feststellung der Positionen von den Rechtecken bestimmen, ob eine Größe von jedem Rechteck innerhalb eines zuvor bestimmten Größenbereichs der zu erkennenden Zeichen liegt und Positionsdaten nur für Rechtecke erzeugt, die in den Größenbereich fallen.

8. Gerät zur Erkennung von Zeichen wie in Anspruch 6, wobei die Positionsdaten obere, untere, linke und rechte Kanten der Rechtecke in den XY-Koordinaten der Bildspeichermittel repräsentieren.

9. Gerät zur Erkennung von Zeichen wie in Anspruch 7, wobei die erste Liste in einem ersten Tabellenspeicher gespeichert wird; und
wobei die Mittel zur Schrägstellungsberechnung die Positionsdaten der Rechtecke der ersten Liste in der angeordneten Reihenfolge lesen, eine zuvor bestimmte Anzahl von Rechtecken erkennen, in welchen eine untere linke Ecke des einen Rechtecks innerhalb der zuvor bestimmten Entfernungen in den x- und y-Richtungen von einer unteren linken Ecke des vorhergehenden Rechtecks liegt und Erkennen einer Schrägstellung des Belegs, der auf den Positionen der unteren linken Ecke der erkannten Rechtecke basiert und wobei die Mittel zur Festlegung aller Rechtecke, aus denen jede Zeichenreihe gebildet wird, schrittweise erneut die Positionsdaten der Rechtecke von der ersten Liste in der angeordneten Reihenfolge zu lesen, um eine virtuelle Position von jedem Rechteck zu erzeugen, das eine durch die Schrägstellung korrigierte y-Achsen Position hat, Speicherung einer virtuellen Position, die sich in der höchsten Position des Belegs in einem Register befindet, erneut schrittweises Lesen der Positionsdaten der ersten Liste in der angeordneten Reihenfolge, um die virtuellen Positionen der Rechtecke zu erzeugen, festzulegen, ob die erzeugten, virtuellen Positionen in einen zuvor bestimmten Bereich von der virtuellen Position in dem Register fallen und Übertragen der Positionsdaten des Rechtecks, deren virtuelle Position in den zuvor bestimmten Bereich einer zweiten Liste fallen.

Revendications

1. Procédé de reconnaissance de caractères imprimés sur un document, les caractères étant agencés sur le document en rangées de caractères, le procédé comprenant les étapes de:
emmagasiner une image du document dans des moyens d'emmagasinage d'image;
déterminer dans l'image emmagasinée les positions de coordonnées XY de rectangles qui sont parallèles aux axes X et Y, chaque rectangle définissant la limite extérieure de l'image d'un caractère et étant formé en détectant la continuité d'une image de caractère sur des lignes binaires successives de l'image;
former une première liste des données de position de rectangle dans laquelle les rectangles sont agencés en ordre le long de l'axe X de l'image emmagasinée suivant leurs données de position de coordonnées d'axe X;
déterminer l'identité d'une pluralité de rectangles comme étant dans une rangée de caractères particulière en détectant si la position d'un point prédéfini sur chacun de ces rectangles tombe dans une zone prédéterminée définie par rapport à un autre de ces rectangles dans la première liste et en prenant comme base les données de position des rectangles identifiés calculant l'angle d'inclinaison de

la rangée de caractères fait avec les coordonnées XY des moyens d'emmagasinage d'image;

en prenant comme base l'angle d'inclinaison calculé, déterminer tous les rectangles constitutifs de chaque rangée de caractères, et ré-agencer les données de position de rectangle en une deuxième liste en qualité de membre d'une rangée de caractères;

fournir à partir des moyens d'emmagasinage d'image sur des moyens de reconnaissance de caractères, les données d'image dans chacun des rectangles dans l'ordre spécifié dans la deuxième liste.

2. Procédé selon la revendication 1, dans lequel l'étape de déterminer la position des rectangles, comprend une étape pour déterminer si chaque rectangle a une taille qui tombe dans une gamme de tailles prédéterminée pour les caractères à reconnaître et, durant l'étape de former une liste de données de position, ne pas tenir compte des rectangles qui tombent hors de la gamme.

3. Procédé selon la revendication 1, dans lequel les données de position représentent la position de bords supérieur, inférieur, gauche et droit du rectangle dans les coordonnées XY.

4. Procédé selon la revendication 1, dans lequel l'étape de déterminer l'identité d'une pluralité de rectangles dans une rangée de caractères particulière, comprend une étape de recherche de la première liste pour détecter un nombre prédéterminé de rectangles, un coin gauche inférieur d'un rectangle étant placé à l'intérieur d'un distance prédéterminée dans les axes X et Y à partir d'un coin gauche inférieur du rectangle précédent, et une étape de calculs de la position des coins inférieurs gauches des rectangles détectés pour détecter l'inclinaison de la rangée de caractères, et, partant, du document.

5. Procédé selon la revendication 1, dans lequel l'étape de déterminer tous les rectangles constitutifs dans chaque rangée de caractères, comprend les étapes de:

lire successivement les données de position des rectangles dans la première liste dans l'ordre agencé;

engendrer une position virtuelle de chaque rectangle en corrigeant la position dans l'axe Y de chaque rectangle dans la première liste, par l'inclinaison;

emmagasiner dans un registre la position virtuelle du rectangle placé à la position supérieure sur le document;

lire à nouveau successivement les données de position des rectangles dans la première liste;

engendrer la position virtuelle de chaque rectangle et déterminer si la position virtuelle engendrée tombe dans une gamme prédéterminée à partir de la position virtuelle emmagasinée dans le registre; et

transférer les données de position d'un rectangle dans la première liste dont la position virtuelle engendrée tombe dans la gamme prédéterminée, sur la deuxième liste.

6. Appareil de reconnaissance de caractères pour reconnaître des caractères imprimés sur un document, comprenant:

des moyens d'emmagasinage d'image (23) pour emmagasiner une image du document;

des moyens (24) pour déterminer dans l'image emmagasinée, les positions de coordonnées XY de rectangles qui sont parallèles aux axes X et Y, chaque rectangle définissant la limite extérieure de l'image d'un caractère et étant formé en détectant la continuité d'une image de caractère sur des lignes binaires successives de l'image;

des moyens pour former une première liste des données de position de rectangle dans laquelle les rectangles sont agencés en ordre le long de l'axe X de l'image emmagasinée suivant leurs données de position de coordonnées d'axe X.

des moyens de calcul d'inclinaison (26)pour déterminer l'identité d'une pluralité de rectangles comme étant dans une rangée de caractères particulière en détectant si la position d'un point prédéfini sur chacun de ces rectangles tombe dans une zone prédéterminée définie par rapport à un autre de ces rectangles dans la première liste et en prenant comme base les données de position des rectangles identifiés calculant l'angle d'inclinaison de la rangée de caractères fait avec les coordonnées XY des moyens d'emmagasinage d'image;

des moyens (27) pour déterminer tous les rectangles constitutifs de chaque rangée de caractères en prenant comme base l'angle d'inclinaison calculé, et pour ré-agencer les données de position de rectangle en une deuxième liste (30) en qualité de membre d'une rangée de caractères;

des moyens de reconnaissance de caractères (31) pour extraire des moyens d'emmagasinage d'image, les données d'image dans chacun des rectangles dans l'ordre spécifié dans la deuxième liste.

7. Appareil de reconnaissance de caractères selon la revendication 6, dans lequel les moyens pour déterminer la positions des rectangles déterminent si une taille de chaque rectangle tombe dans une gamme de tailles prédéterminée des caractères à reconnaître, et engendrent les données de position uniquement pour les rectangles tombant dans la gamme de tailles.

8. Appareil de reconnaissance de caractères selon la revendication 6, dans lequel les données de position représentent les bords supérieur, inférieur, gauche et droit des rectangles dans les coordonnées XY des moyens d'emmagasinage d'image.

9. Appareil de reconnaissance de caractères selon la revendication 7, dans lequel la première liste est emmagasinée dans une première mémoire de tables; et

dans lequel les moyens de calcul d'inclinaison lisent successivement les données de position des rectangles de la première liste dans l'ordre agencé, détectent un nombre prédéterminé de rectangles, dans lequel un coin gauche inférieur d'un rectangle est placé à l'intérieur des distances prédéterminées dans les directions X et Y à partir du coin gauche inférieur du rectangle précédent, et détectent une inclinaison du document basée sur la position du coin gauche inférieur des rectangles détectés, et dans lequel les moyens pour déterminer tous les rectangles constitutifs de chaque rangée de caractères, lisent successivement à nouveau les données de position des rectangles de la première liste dans l'ordre agencé pour engendrer une position virtuelle de chaque rectangle qui est une position d'axe Y corrigée par l'inclinaison, emmagasinant une position virtuelle placée à la position la plus haute du document dans un registre, lisent successivement à nouveau les données de position de la première liste dans l'ordre agencé pour engendrer la position virtuelle des rectangles, déterminent si les positions virtuelles engendrées tombent dans une gamme prédéterminée à partir de la position virtuelle dans le registre, et transfèrent les données de position de rectangle dont la position virtuelle tombe dans la gamme prédéterminée, sur une deuxième liste.

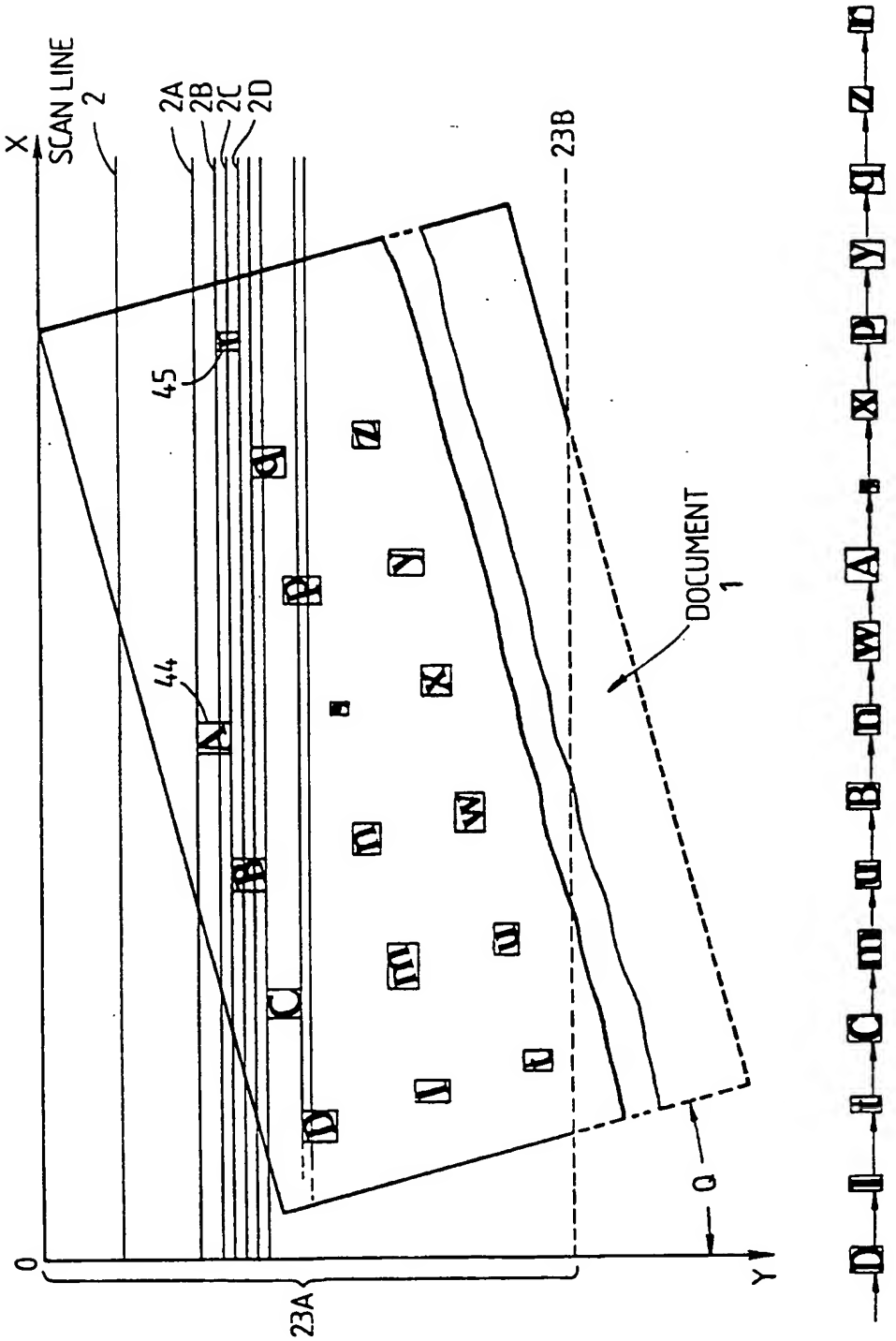


FIG. 1A

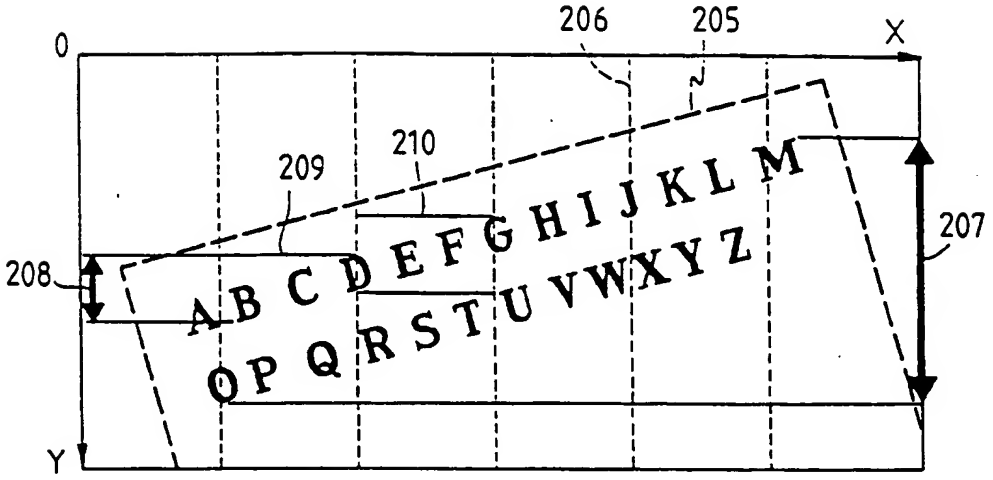

0
206
205
X
209
210
208
207
A B C D E F G H I J K L M
O P Q R S T U V W X Y Z
Y

FIG. 1C

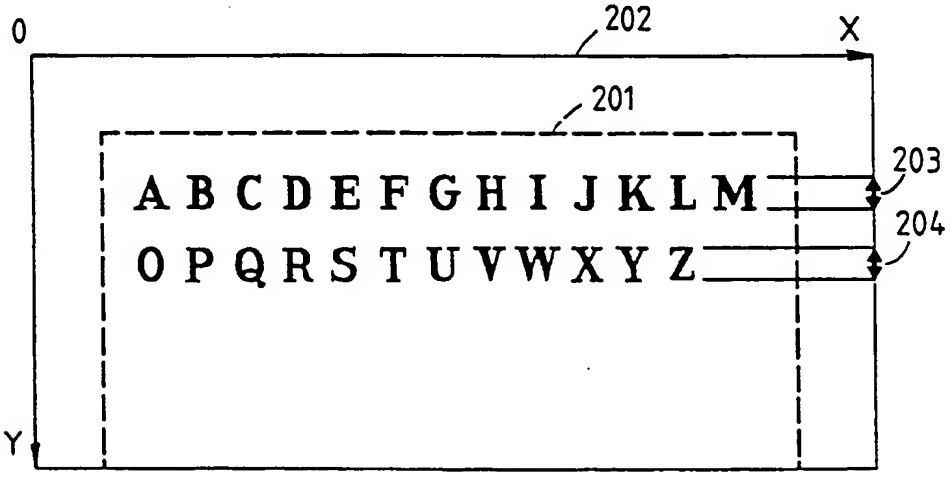

0
202
X
201
203
204
A B C D E F G H I J K L M
O P Q R S T U V W X Y Z
Y

FIG. 1B

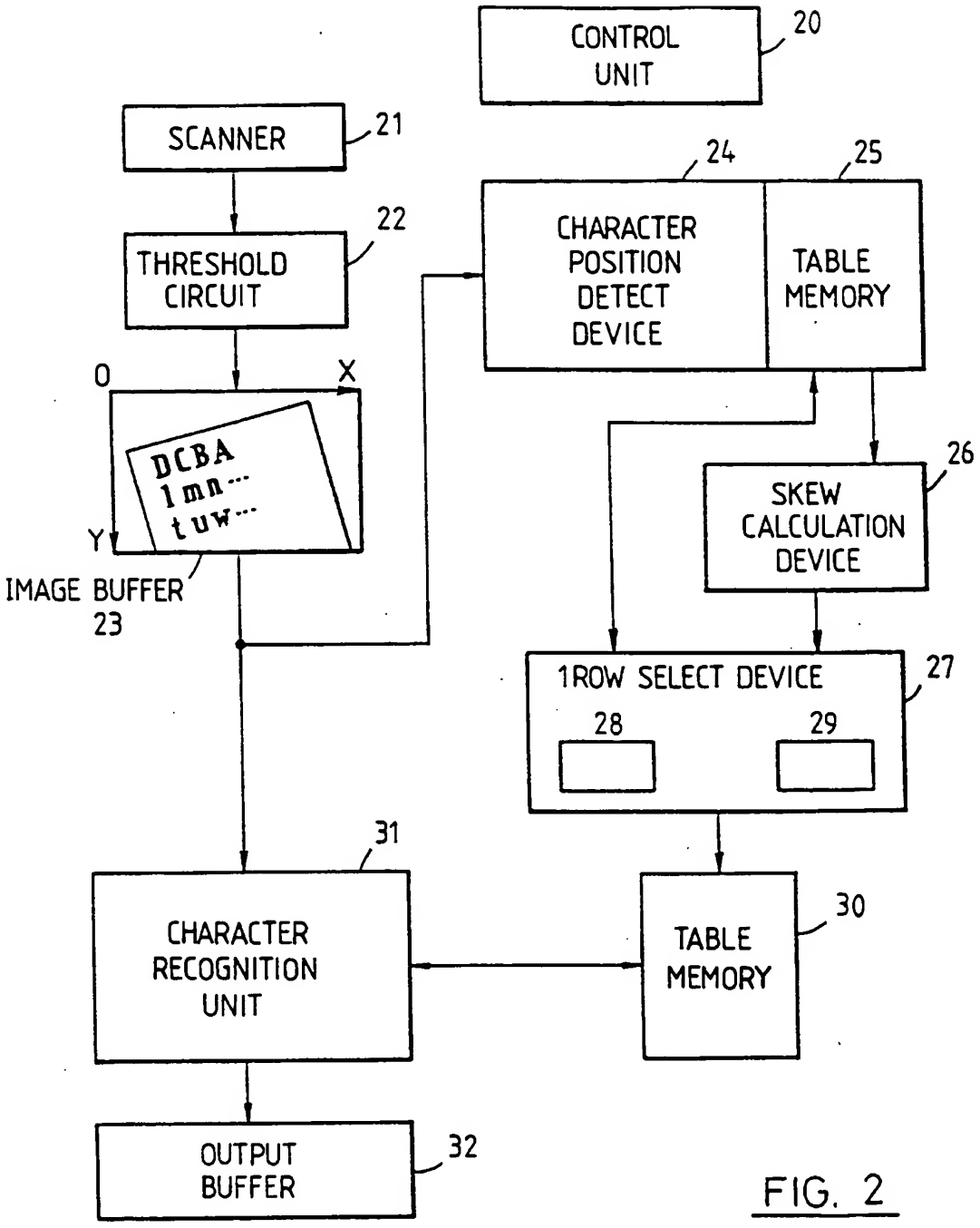
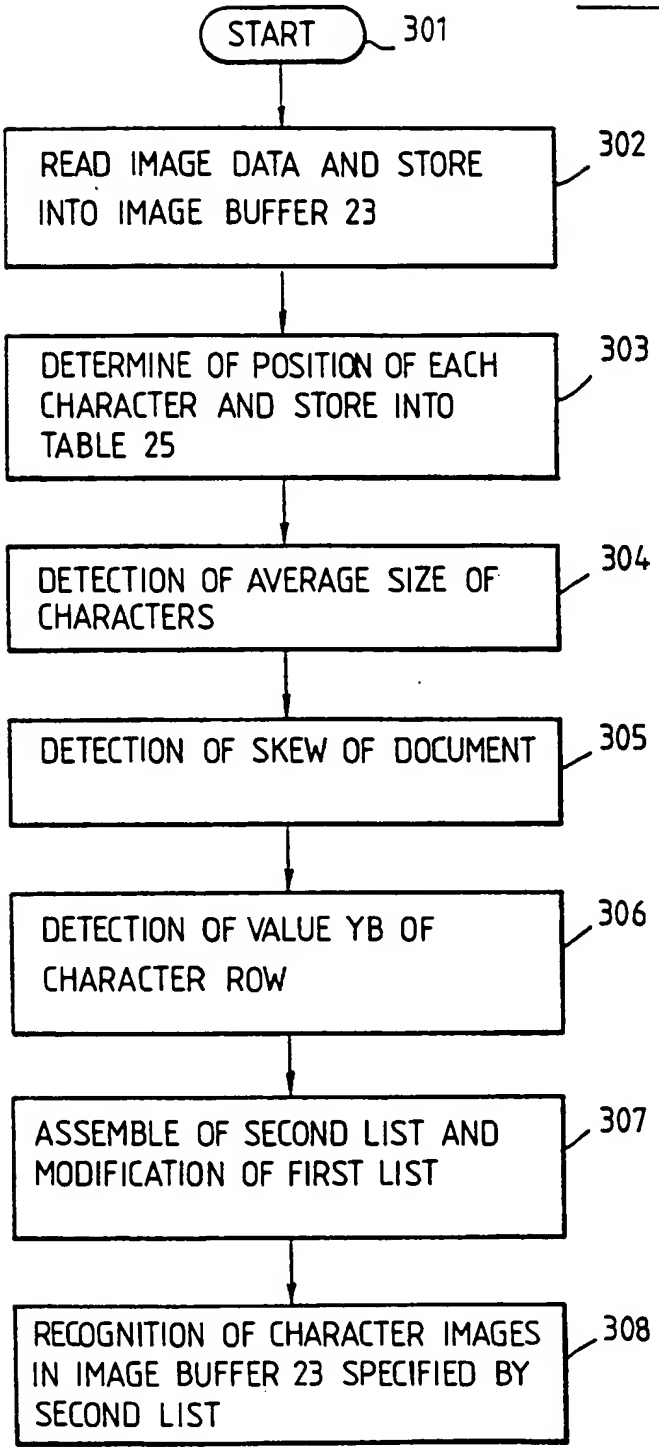

CONTROL UNIT
20
SCANNER
21
THRESHOLD CIRCUIT
22
24
25
CHARACTER POSITION DETECT DEVICE
TABLE MEMORY
0
X
Y
DCBA
1mn...
tuw...
IMAGE BUFFER
23
26
SKEW CALCULATION DEVICE
1ROW SELECT DEVICE
27
28
29
31
CHARACTER RECOGNITION UNIT
TABLE MEMORY
30
OUTPUT BUFFER
32

FIG. 2

FIG. 3


START
301
READ IMAGE DATA AND STORE INTO IMAGE BUFFER 23
302
DETERMINE OF POSITION OF EACH CHARACTER AND STORE INTO TABLE 25
303
DETECTION OF AVERAGE SIZE OF CHARACTERS
304
DETECTION OF SKEW OF DOCUMENT
305
DETECTION OF VALUE YB OF CHARACTER ROW
306
ASSEMBLE OF SECOND LIST AND MODIFICATION OF FIRST LIST
307
RECOGNITION OF CHARACTER IMAGES IN IMAGE BUFFER 23 SPECIFIED BY SECOND LIST
308

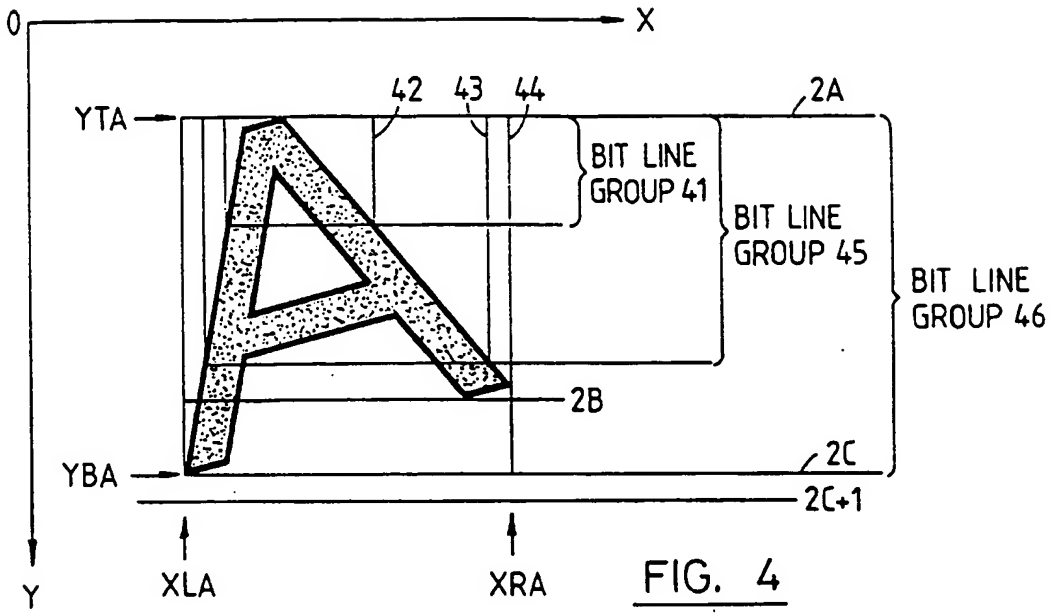

0
X
42
43
44
2A
YTA
BIT LINE GROUP 41
BIT LINE GROUP 45
BIT LINE GROUP 46
2B
2C
YBA
2C+1
Y
XLA
XRA

FIG. 4

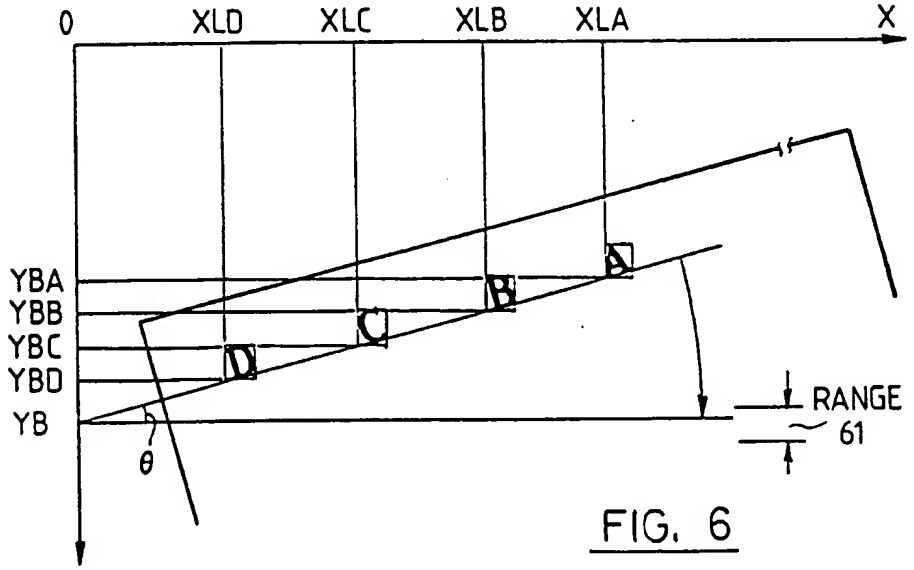

0
XLD
XLC
XLB
XLA
X
YBA
YBB
YBC
YBD
YB
A
B
C
D
θ
RANGE
61

FIG. 6

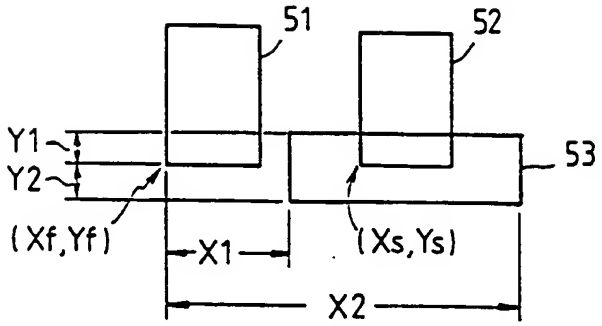


FIG. 5A

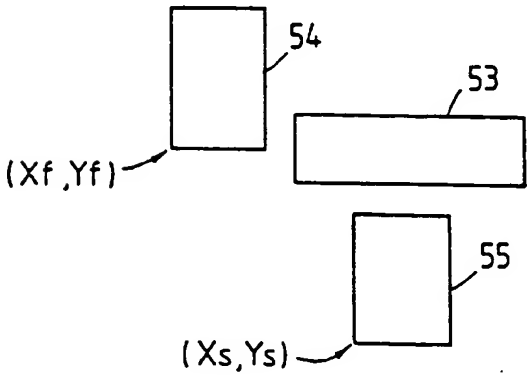


FIG. 5B

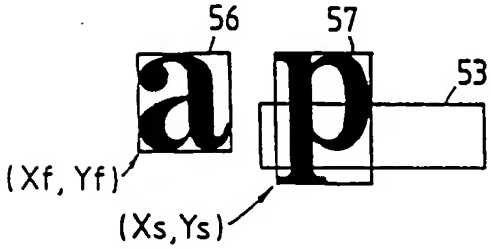


FIG. 5C